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Wholesale suppliers at fuel terminals blend gasoline with ethanol to create finished gasoline. Under the US Renewable Fuel Standard (RFS), this blending activity produces a renewable fuel credit, known as a RIN, which blenders can sell to oil refiners who need it for RFS compliance. We estimate whether these suppliers, known as rack sellers, pass through the value of RINS. Based on a population-weighted regression with 20 large cities, we estimate a 63% RIN pass through for branded fuel (95% confidence interval [0.23, 1.03]) and a 92% pass through for unbranded fuel (95% CI [0.70, 1.14]). The confidence intervals on the pooled national regressions are wide and include full pass-through. When we estimate pass-through in regions, we find that suppliers pass through the RIN value in the Midwest – the so-called ethanol belt – and in the Gulf states. The estimates for the Midwest are 0.86 (branded, 95% CI [0.63, 1.09]) and 0.99 (unbranded, 95% CI [0.83, 1.16]). The estimates for the Gulf region are 0.88 (branded, 95% CI [0.74, 1.02]) and 0.89 (branded, 95% CI [0.76, 1.02]). In contrast, we find incomplete passthrough in Eastern cities, with estimates of 0.38 (branded, 95% CI [0.13, 0.63]) and 0.50 (unbranded, 95% CI [0.14, 0.85]); for the East, these confidence intervals do not include one. Price spreads in the West are too volatile to estimate RIN pass through precisely in that region. We also find that passthrough of RIN values to E10 prices is complete at terminals that offer multiple blends, but is incomplete (especially for branded fuels) at terminals that offer neither pure ethanol nor higher blends. The incomplete pass-through we find is a sign of too little competition at some terminals and in some regions, and that incomplete pass-through reduces the efficiency of the RIN program.

Disciplines

Agricultural and Resource Economics | Behavioral Economics | Growth and Development | Oil, Gas, and Energy | Regional Economics

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Abstract

Wholesale suppliers at fuel terminals blend gasoline with ethanol to create finished gasoline. Under the US Renewable Fuel Standard (RFS), this blending activity produces a renewable fuel credit, known as a RIN, which blenders can sell to oil refiners who need it for RFS compliance. We estimate whether these suppliers, known as rack sellers, pass through the value of RINS. Based on a population-weighted regression with 20 large cities, we estimate a 63% RIN pass through for branded fuel (95% confidence interval [0.23, 1.03]) and a 92% pass through for unbranded fuel (95% CI [0.70, 1.14]). The confidence intervals on the pooled national regressions are wide and include full pass-through. When we estimate pass-through in regions, we find that suppliers pass through the RIN value in the Midwest – the so-called ethanol belt – and in the Gulf states. The estimates for the Midwest are 0.86 (branded, 95% CI [0.63, 1.09]) and 0.99 (unbranded, 95% CI [0.83, 1.16]). The estimates for the Gulf region are 0.88 (branded, 95% CI [0.74, 1.02]) and 0.89 (branded, 95% CI [0.76, 1.02]). In contrast, we find incomplete pass-through in Eastern cities, with estimates of 0.38 (branded, 95% CI [0.13, 0.63]) and 0.50 (unbranded, 95% CI [0.14, 0.85]); for the East, these confidence intervals do not include one. Price spreads in the West are too volatile to estimate RIN pass through precisely in that region. We also find that pass-through of RIN values to E10 prices is complete at terminals that offer multiple blends, but is incomplete (especially for branded fuels) at terminals that offer neither pure ethanol nor higher blends. The incomplete pass-through we find is a sign of too little competition at some terminals and in some regions, and that incomplete pass-through reduces the efficiency of the RIN program.

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1. Introduction

The Renewable Fuel Standard (RFS) mandates biofuel blending levels in motor fuels in the United States. The Environment Protection Agency (EPA) implements the RFS by specifying annual blending fractions for different categories of renewable fuels. Owners of oil refineries and importers of gasoline and diesel are obligated under the RFS to show compliance with blending requirements. They comply by acquiring sufficient Renewable Identification Numbers (RINs) during the year and submitting them to EPA. Biofuel production generates RINs. RINs remain attached to biofuel until the biofuel is blended with gasoline or diesel into motor fuel. Once detached, RINs become a tradeable commodity that obligated parties can purchase. The price of RINs bridges the gap between the marginal cost of producing biofuel and the liquid value of that biofuel to blenders. Hence, RINs serve two roles: 1) they provide a means of complying with the RFS; and 2) they in effect tax petroleum fuels to provide a subsidy to renewable fuels.

Figure 1 illustrates the gasoline supply chain and the RFS compliance mechanism. We focus here on the supply chain for conventional (corn) ethanol and gasoline. In the nested structure of the RFS, the price of RINs for other biofuels can affect the price of RINs for conventional ethanol but we simplify matters here for clarity. Figure 1 shows a retail sector with two gasoline blends: 1) E10, which is regular gasoline and contains no more than 10 percent gasoline, and 2) E85, which contains between 51 and 83 percent ethanol.

When the supply chain is perfectly competitive, the RIN compliance mechanism minimizes the cost of RFS compliance. To see this, suppose EPA increases an already-binding ethanol mandate. This increase will widen the gap between the marginal cost of producing ethanol and the fuel value of ethanol in blended fuel. Because the price of RINs bridges this gap, RIN prices will increase. The lower value of ethanol going into blending fuels lowers the per-gallon cost of producing E85 much more than E10 because E85 contains more ethanol. This unequal impact creates an incentive for blenders to produce and market greater quantities of E85 which, in turn, facilitates compliance with the increased ethanol mandate. The higher RIN price also results in a higher effective tax on gasoline. In a perfectly competitive market, the higher effective gasoline tax propagates through the system so that in equilibrium part of the tax is paid by refineries, and part is paid by blenders and consumers through higher gasoline prices. The tax incidence depends on the relevant elasticities of demand and supply (Pouliot and Babcock 2016).

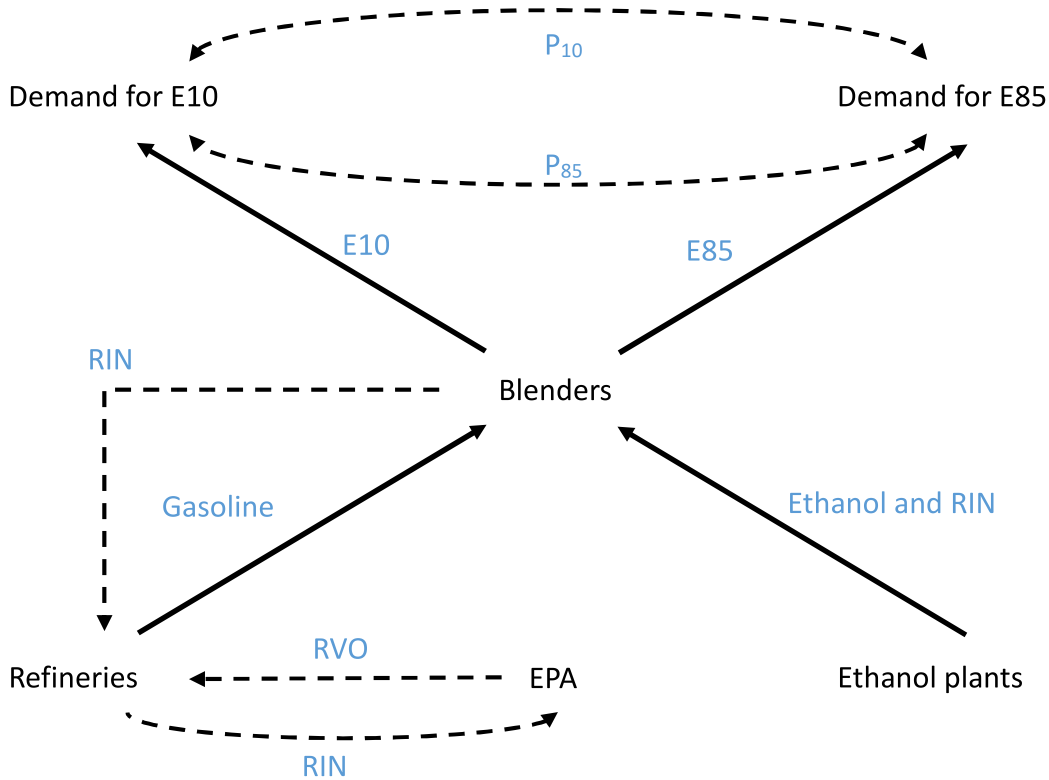


Figure 1: Compliance structure with the RFS

In the summer and fall 2016, several parties petitioned EPA to change the point of RFS obligation from the refiners to rack sellers.[2] Specifically, the proposal was to redefine an obligated party as the "entity that holds title to the gasoline or diesel fuel, immediately prior to the sale from the bulk transfer/terminal system, (as defined by IRS regulation 40 CFR §48.4081-1) to a wholesaler, retailer or ultimate consumer and is required to report any federal tax liability for gasoline or diesel on its Form 720" (p. 7 in Valero, 2016). Rack sellers include owners of distribution terminals, fuel distributors that lease tank space within terminals and use terminal services to blend fuels that they own. They also include refiners who continue to own the fuel through the point of blending.

Petitioners hypothesize that rack sellers partially capture the value of the RIN rather than passing it along the supply chain. However, the economically efficient working of the RIN system requires that increases in RIN prices are passed along to the consumer in the form of higher pump prices for fuels that have a low renewable content and lower prices for fuels with a high renewable content. If

[2] A "rack" is where fuel delivery trucks are filled up in fuel terminals.

the price of the RINs does not get passed through to pump prices, then it does not play its role to incentivize consumption of ethanol in motor fuel. A first step to determining whether the RIN mechanism is working properly is to estimate whether RIN prices are fully passed through along the supply chain, as they would be under perfect competition.

Previous studies provide evidence that the RIN system works properly at certain stages of the motor fuel supply chain. Knittel, Meiselman and Stock (2016a,b) find evidence of full RIN pass-through in bulk markets, indicating that the RIN system at that stage of the supply chain works as designed. Burkhardt (2016) estimates that in 2013 and 2014 refineries more than fully passed their cost of RINs down to the wholesale market, however his findings are statistically not different than complete pass-through. Lade and Bushnell (2016) and Li and Stock (2017) study RIN pass-through at retail for high-ethanol gasoline blends in fuel stations in Minnesota (Li and Stock) and in Minnesota, Iowa, and Illinois (Lade and Bushnell). Both studies find complete pass-through in urban areas where there is competition for high-ethanol gasoline blends. However, in areas where there is less competition at retail for high-ethanol gasoline blends, Lade and Bushnell (2016) and Li and Stock (2017) find an imperfect RIN pass-through. Because most consumers live in urban areas, where there is a high degree of pass-through, their results show that, for the three Midwestern states they study, that the RIN market works as designed. Li and Stock (2017) also examine pass-through from bulk wholesale prices to rack prices, however their data set includes only 12 racks, only has monthly data, and only examines pass-through to higher blends, not to E10.

This paper fills this gap by examining daily data on rack prices and upstream bulk wholesale fuel prices to estimate the pass-through of RIN prices to rack prices. The data set consists of a total of 6,753,219 observations on daily rack prices in 57 cities. We find incomplete pass-through at the rack for E10, which is informative about the current RIN system. In particular, these findings indicate that, at many terminals, fuel suppliers are exercising market power and retaining some of the RIN premium. As a result, the RIN value is not being fully passed through to consumers. These findings do indicate that the RIN system does not function in the most efficient manner.

These findings indicate that there is market power at some racks, in the sense of incomplete pass-through. While these findings are relevant to the question of moving the Point of Obligation, by themselves they are insufficient to conclude that shifting the Point of Obligation would improve pass-through and economic efficiency.

We begin by providing background information about the gasoline and ethanol markets. We then describe our data and show empirical evidence about the pass-through of RIN prices at the rack.

2. Ethanol market background

The gasoline distribution system was set up in the 20th century to minimize the cost of bringing gasoline from refiners to consumers. It is based on an extensive pipeline system that transports gasoline from refineries to terminals in population centers. Trucks deliver gasoline from terminals to retail outlets. The least-cost way of adding ethanol to motor fuel was to add on new infrastructure to the existing gasoline distribution system. This new infrastructure needed to account for specific properties of ethanol such as its corrosiveness and its solubility with water, both of which prevent transportation of ethanol through existing pipelines. Instead, ethanol is transported from plants to terminals either by rail or by truck. New ethanol tanks and rack outlets were constructed at many terminals to receive the ethanol and facilitate blending with gasoline. Currently about 98% of non-diesel motor fuel contains 10% ethanol, which demonstrates the extent to which required blending infrastructure has been installed.

2.1. Major Fuel Markets

Bulk markets are situated in areas of the country where fuel companies trade large quantities of motor fuel and where market prices are determined. There are six recognized bulk markets: 1) the Gulf (Texas), 2) New York Harbor, 3) Chicago, 4) Group 3 (Great Plains states), 5) West Coast, and 6) Pacific Northwest. Gasoline prices at other locations are typically quoted in terms of a basis relative to bulk market prices. Prices for ethanol are set in the same manner. Any bulk market can be used as the reference price and which bulk market to use is agreed upon by sellers and buyers of fuel. It is most common to use the bulk market that is closest to the location where the transaction takes place.

2.2. Distribution Terminals

From the bulk markets, gasoline flows to distribution terminals by pipeline, water, rail or trucks. Ethanol plants often ship directly to distribution terminals although in some cases the ethanol is delivered to major terminals and then re-distributed to regional terminals. Each terminal has a rack, at which one or more suppliers, also known as rack sellers, post prices for fuel. Rack sellers acquire bulk gasoline and ethanol, blend it, and then sell it to retailers. Fuel retailers may also buy bulk fuel above the rack and use a terminal’s facilities to blend it into a finished product. Such firms do not post rack prices because they do not sell fuel at the rack.

We refer to terminals that lease capacity to any rack seller or retailer as open terminals. However, some distribution terminals may not provide open access to their facilities, and we refer to these as closed terminals. These terminals are typically owned by major oil companies, and can include terminals owned by a refiner at a refinery gate. At an open terminal, a rack seller or retail chain may lease space in ethanol and gasoline tanks so that it can buy fuel in bulk. Having their own supply of bulk fuel gives retail chains an option to use their own ethanol if the prices being offered at the rack by sellers are too high. The ability to arbitrage price differences suggests that ethanol and gasoline prices at open terminals should be more competitive than prices at terminals that do not.[3]

The cost of handling ethanol at these terminals typically ranges from 3.5 to 4 cents per gallon. This cost is significantly higher than the 0.8 to 1 cent per gallon for petroleum gasoline blendstock. In some pipeline systems, the higher cost reflects the fact that ethanol replaces petroleum gasoline at these terminals, and the terminal owner typically charges 3 cents for gasoline delivered via its pipeline. In other systems, the higher cost reflects recovery of the cost of installing ethanol infrastructure at the terminal. Overall, a 3 cent higher cost for handling ethanol seems to be an accepted practice at distribution terminals.

Rack prices refer to fuel prices "over the rack" delivered into a truck. Each company posts their offer prices available at that price. At an open terminal, a fuel buyer can choose the seller that offers the best combination of price arbitrage between all the fuels available. A buyer can choose to purchase E10, in which case the terminal is the blender. In some mid-continent markets, a buyer can choose to purchase E0 and E100 and splash blend these fuels to make E10. In that case, the buyer becomes the fuel blender, although splash blending to make E10 is rare.

2.3. Ethanol shipments

Every ethanol plant has options about where to can sell their ethanol. Plants typically hire brokers firms to market their ethanol for them. Ethanol shipped long distances travels by train, sometimes in unit trains of 100 cars. Truck transportation also occurs for shorter-hauls. We expect the market for ethanol to be competitive throughout the country because there are many ethanol plants and many ethanol buyers throughout the United States. Higher ethanol prices outside the Midwest should be expected because of the higher transportation costs.

[3] This statement assumes that the rack sellers and retail chains would be able to access pipeline space to get bulk gasoline to the terminal.

3. Definition and interpretation of RIN Pass-through

Our focus is on estimating the pass-through of the RIN at the rack. To understand what we mean by the RIN pass-through, consider the rack price for a finished gasoline blend. The blender purchases ethanol at a price p^e, which includes the value of the RIN, and purchases gasoline at a price p^g. The blend rate of ethanol into the final fuel is δ (e.g. 10 percent). We define the spread as the difference between the price at which the blended fuel is sold, p^f, and the cost of acquiring the bulk fuel, i.e.,

$$spread = p^f - \delta p^e - (1-\delta) p^g \ . \tag{1}$$

We define the wet fuel cost as

$$wc = \delta p^e + (1-\delta) p^g$$

By blending ethanol into a gallon of fuel, the blender generates δ RIN, which it can sell at price ρ. The per-gallon blender profit is therefore

$$profit = spread + R - c_f = p_f + R - wc - c_f \ , \tag{2}$$

where $R=\delta\rho$ denotes RIN revenue and c_f denotes the cost of terminaling and blending the fuel.

Consider an increase in the RIN price. Competitive blenders would respond to the resulting increase in revenue by reducing their rack price and thereby reducing the spread. In a perfectly competitive market, these price reductions would continue until the spread had decreased by enough to offset the RIN price increase and return profits to zero. This is an example of perfect pass-through. If the market is less than perfectly competitive, then blenders may be able to retain some of the RIN revenue without passing it through to consumers. For a firm that passes through a proportion β of the RIN revenue, we can write using the definition of the spread

$$spread = c_f - \beta R \ , \tag{3}$$

For example, suppose β=0.6 and RIN revenue increases from 0 to $0.10. The firm reduces its spread by 6 cents and retains the remaining 4 cent as profit. Values of β less than one indicate imperfect, or partial, pass-through.

In empirical studies, the usual interpretation of an imperfect pass-through is that it is a signal of market power. In the case of the RIN system, imperfect competition at a stage of the supply chain means that the firms with market power can shift the incidence of the policy away from them and possibly profit from the RIN system. A regression that shows an imperfect pass-through, however, does not tell us whether a blender exercises market power in selling the blended fuel, in purchasing gasoline blendstock or ethanol or in selling RINs.

A supplier at a terminal is not likely to be able to exercise market power in the purchase of gasoline. Several refineries typically supply a terminal (Borenstein and Shepard, 2002). Gasoline can be shipped over long distance at a relatively low cost. Although transient shifts in storage capacity and pipeline space constraints can in effect create local markets for bulk petroleum products, over the medium and longer run the ability of refiners to sell refined product at multiple terminals provides for competition among terminals. Similarly, ethanol is transported by train and trucks, produced in more than 100 facilities and is shipped throughout the United States, providing for competition among terminals for ethanol.

The potential for a single supplier to exercise market power in the RIN market is limited. The RIN market is nationwide and there are numerous blenders selling RINs and numerous refineries demanding RINs. A supplier with market power would use it to raise the price of RINs. For a single supplier in a single market this is unlikely because it cannot influence the number of RINs nationwide. A vertically integrated firm with control over many terminals would have market power in the RIN market if it were large enough to influence to total quantity of ethanol supplied.

Where a supplier is most likely to be able to exercise market power is when it sells gasoline blends to distributors. Indeed, there is evidence that some terminals exercise market power in the fuel they sell (e.g. Borenstein and Shepard, 2002; Hastings and Gilbert, 2005). As discussed above, local market power can manifest itself only when the terminal remains closed to limit competition at its facilities. Another manifestation of market power is a markup that covers more than its cost. This markup adjusts to variations in fuel costs and the price of RIN. Thus, although the RIN is valued at market price, there can be an imperfect pass-through of the RIN because a blender has market power and is able to retain part of the RIN value.

4. Data description

We use data for prices at the rack to estimate the pass-through of RIN price into the price of gasoline blends. We focus on gasoline blends and because virtually all ethanol blended with gasoline is from corn ethanol, we only consider the pass-through of the price of D6 RINs.

4.1. Fuel price data

We use OPIS data on daily rack prices at distribution terminals for 57 cities. We selected cities for the dataset with three objectives. First, to cover the most important gasoline markets, we desired a broad geographic distribution of major cities. Second, to study markets that have high-ethanol-blend fuels, we included populous cities with multiple parties actively posting prices for such fuels. Third, to obtain comprehensive coverage in a particular region, we included all terminals in the states of Iowa, Illinois, and Minnesota as well as two border cities in neighboring states, Sioux Falls, SD and Omaha, NE. Thus, the cities in our dataset enter under three scopes:

Scope 1: 10 large cities

Scope 2: E85 cities

Scope 3: 3 states

Figure 1 shows the location of the cities in each scope, and Appendix Table A1 lists the cities. The data cover the period between January 1, 2012 and May 31, 2016. The dataset includes the posted price of each supplier of each product at each terminal in each city each day. Later, in presenting some results, we sort the cities by geographical area. Appendix Table A2 lists the cities by area.

For the main analysis, we select the main E10 product offered in each city. The EPA requires reformulated gasoline (RFG) in cities with high smog levels. In such areas, the relevant E10 product is "RFG Ethanol 10%". In most other cities, the relevant E10 product is denoted "Conv. Ethanol 10%" or "CBOB Ethanol 10%". Exceptions are Phoenix, AZ and the California cities, which have distinct RFG products due to state and local regulations, and Atlanta, GA, which required low-sulfur gasoline until October 2015. Appendix Table A1 lists the E10 products by city.

Not all terminals offer the same products all the time. Figure 2 shows offering of high-blend ethanol for all terminals in Scopes 1 and 2 as well as Wood River, IL (St Louis) and Omaha, NE. Almost all terminals in the Midwest tend to offer high-ethanol blends on a regular basis (see Appendix Table A2 for a list of these cities). In other parts of the country, not all terminals offered high-blend ethanol and in some locations the offer is sporadic. Terminals in California almost never offered high-ethanol blends.

OPIS also supplied bulk prices for gasoline blendstock and ethanol. Where appropriate, we use the OPIS-computed spot replacement index (SRI) as the bulk price of gasoline. OPIS computes this index by taking the spot price in the relevant bulk fuel market and adding the cost of transporting the fuel to the relevant city by pipeline and other costs such line loss due to evaporation in the line and terminaling and storage fees. For markets without a relevant SRI price in the dataset, we use the spot price at the nearest spot market. For bulk ethanol prices, we use the spot price at the relevant spot market. We assign ethanol spot markets to cities based on geography and discussions with industry participants. Appendix Table A1 lists the bulk prices we use for each city.

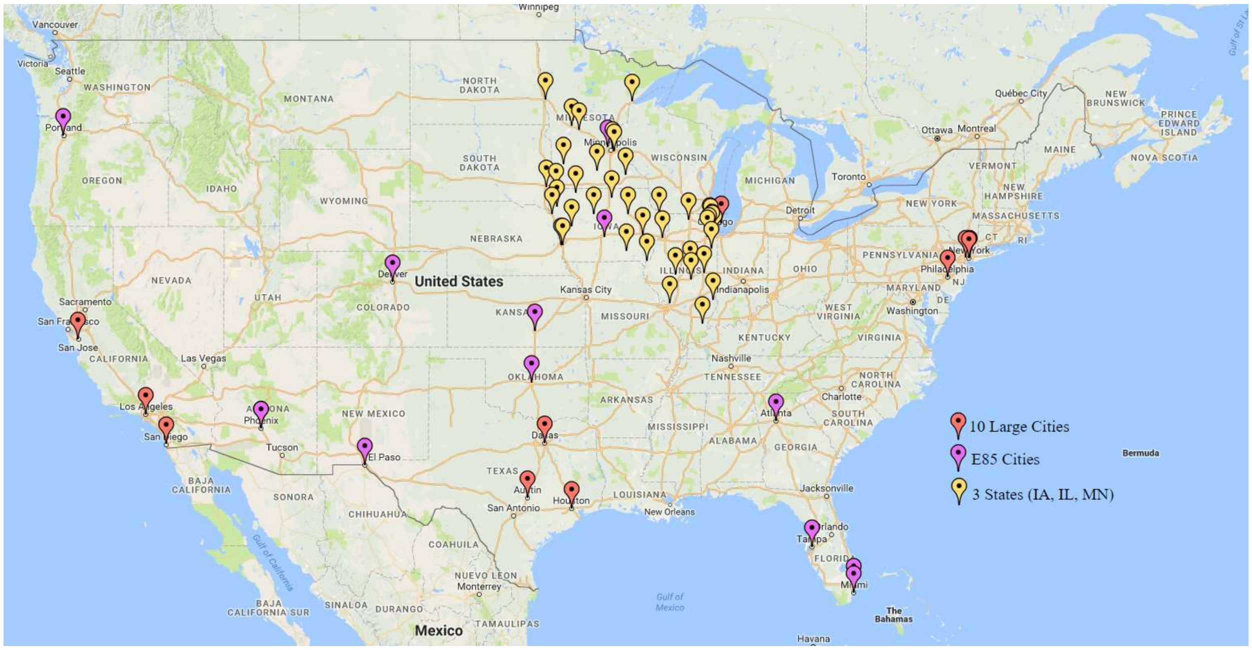


Figure 1: Location of distribution terminals

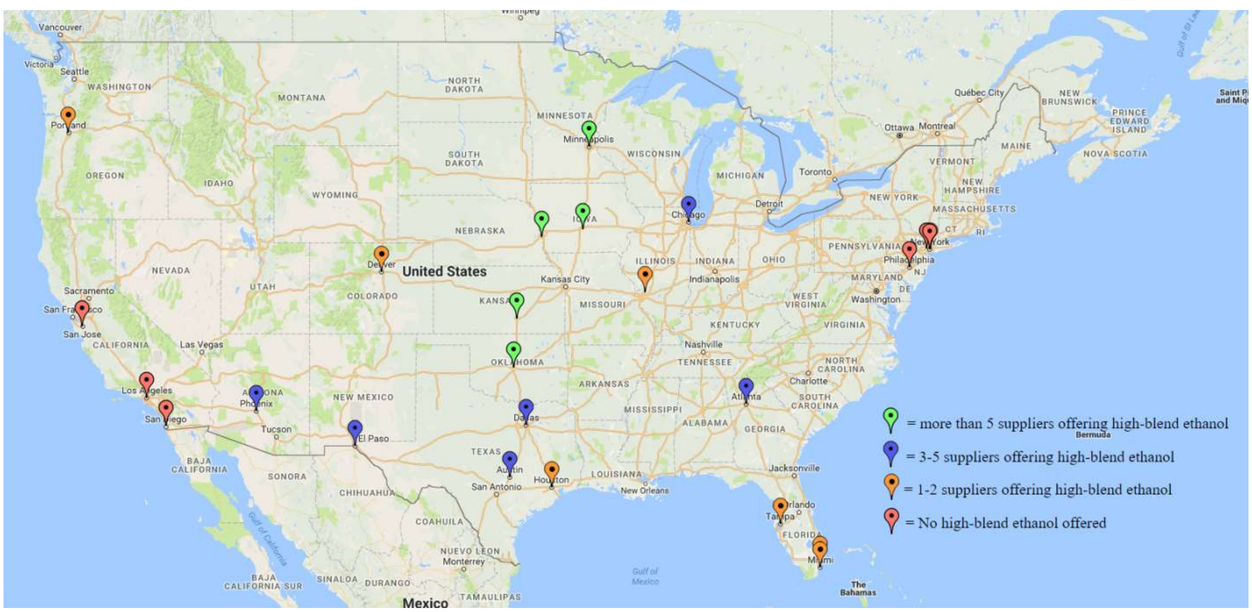


Figure 2: Terminals offering high-blend ethanol

Note: Green pins identify cities where more than 5 suppliers offered high-blend ethanol for at least 500 days, blue pins identify terminals where 3-5 suppliers offered high-blend ethanol for at least 500 days, orange pins identify terminals where 1-2 suppliers offered high-blend ethanol for at least 500 days, and red pins identify cities where no supplier offered high-blend ethanol for at least 500 days.

4.2. RIN prices

OPIS also provided us with the price of D6 RINs, which we plot in Figure 3. Before 2013, the price of RINs was close to zero because the RFS was not a binding constraint on marginal biofuel volumes. The price of RINs sharply increased sharply at the beginning of 2013 and spiked in July 2013. The increase in the RIN price was caused by an increase in the required biofuel volumes beyond that which could be met by E10. The price of RINs declined after the release of the EPA'S 2013 Final Rule in August 2013, in which the agency indicated a likely reduction in the required volumes in future years due to inadequate infrastructure to supply E85 to the market. Lade, Lin and Smith (2016) document that EPA announcements about future expected stringency of the RFS drive RIN prices during this period. After the August 2013 decline two further events caused RIN price drops, an October 2013 leak of the Proposed Rule for 2014 and the November 2013 official release of the 2014 Proposed Rule.

In the ensuing year, there was a period of uncertainty during which the EPA did not release a rule. Three additional EPA announcements caused significant RIN price changes in the latter part of the sample. In November 2014, it delayed release of the 2014 volumes, which the market interpreted as a sign that the EPA was likely to push volumes beyond the blend wall causing RIN prices to increase. However, in June 2015 it announced a Proposed Rule for 2014, 2015 and 2016 that was less aggressive than expected. RIN prices dropped by almost 50%. Finally, in November 2015 it published the Final Rule for 2014, 2015 and 2016. This rule surprised markets by requiring more biofuel than expected, which caused another jump in RIN prices.

Figure 3 delineates the three distinct RIN price periods since the beginning of 2012. The dramatic increase in 2013 clearly caught fuel markets by surprise. If markets participants had been anticipating an increase in RIN prices, they would have been purchasing RINs prior to 2013, which would have pushed prices up sooner. Market observers expressed confusion about the cause of the RIN prices and whether they were justified economically. Some speculated that financial traders were manipulating prices.[4] For suppliers at the rack, adapting to and understanding the new reality of high RIN prices likely took some time. To allow for the possibility that market participants did not adapt immediately to this new market reality, we report pass-through regression results both for the full sample and a sample that omits the RIN shock period (1/1/13-8/31/13).

[4] http://www.nytimes.com/2013/09/15/business/wall-st-exploits-ethanol-credits-and-prices-spike.html

Figure 3: Price of D6 RINs (cents per gallon)

4.3. Margin at the rack

Equation (1) defines the spread as the difference between the price of the blended fuel and its components. Equation (3) expresses the spread as equal to the cost of blending and terminaling minus the proportion of RIN revenue that is passed through, i.e., $spread_f = c_f - \beta R$. In Section 5, we present estimates of β using linear regression. In this section, we present some plots and descriptive statistics of the spread and RIN revenue.

We calculate the spread using one-day lag of the bulk ethanol and gasoline blendstock prices so that the spread on day *t* is measure as

$$spread_t = p_t^f - \delta p_{t-1}^e - (1-\delta) p_{t-1}^g ,$$

The one-day lag captures the fact that rack prices tend to be set based on the previous-day price in bulk markets.

Figure 4 plots the spread for the four largest cities in the US along with the negative of the RIN revenue. Under full pass-through (β=1), the spread would move one-for-one with the negative RIN revenue. With less than perfect pass-through, the spread would change by less than the amount of any changes in RIN revenue.

All four cities show significant high-frequency (day-to-day) variation as well as shocks that persist for several months. Aside from Los Angeles, the spreads are typically less than 10 cents per gallon and trend downwards. This downward trend suggests at least partial RIN pass-through, given that RIN revenue trended upwards during the same period.

The Los Angeles spreads were significantly affected by an explosion at the Exxon Mobil refinery in Torrance, CA on February 18, 2015. This event, which occurred at a refinery that accounts for 20% of Southern California capacity, caused an immediate increase in gasoline spreads and prices in the state, especially in Southern California. Los Angeles prices were as much as $1 per gallon higher than the US average in the ensuing months and averaged $0.70 above the US average between the explosion and the end of our sample. Based on historical averages and accounting for the California cap and trade program, Los Angeles prices should average about $0.40 more than the national average, so this event generated a persistent $0.30 premium.[5] During this same period, as Figure 4 shows, the rack spread averaged about $0.15.

The refinery restarted in May 2016, which is at the end of our sample. However, it is somewhat surprising that sufficient imports did not enter that state to bring the price premiums down before the restart. The California Energy Commission's Petroleum Market Advisory Committee continues to investigate this episode in an attempt to understand why prices remained so high for so long.[6] In our analysis, we account for this event by including a dummy variable in our regressions for the post-Torrance-explosion observations. We include this dummy separately for San Diego, Los Angeles, and San Jose. This approach may lead us to over-estimate pass-through in these cities. RIN revenue increased during this post-Torrance period and there may have been some mean reversion from the Torrance event. These concurrent trends would bias our results towards finding pass-through.

[5] https://energyathaas.wordpress.com/2015/09/28/why-are-californias-gasoline-prices-so-high/
[6] http://www.energy.ca.gov/assessments/petroleum_market/

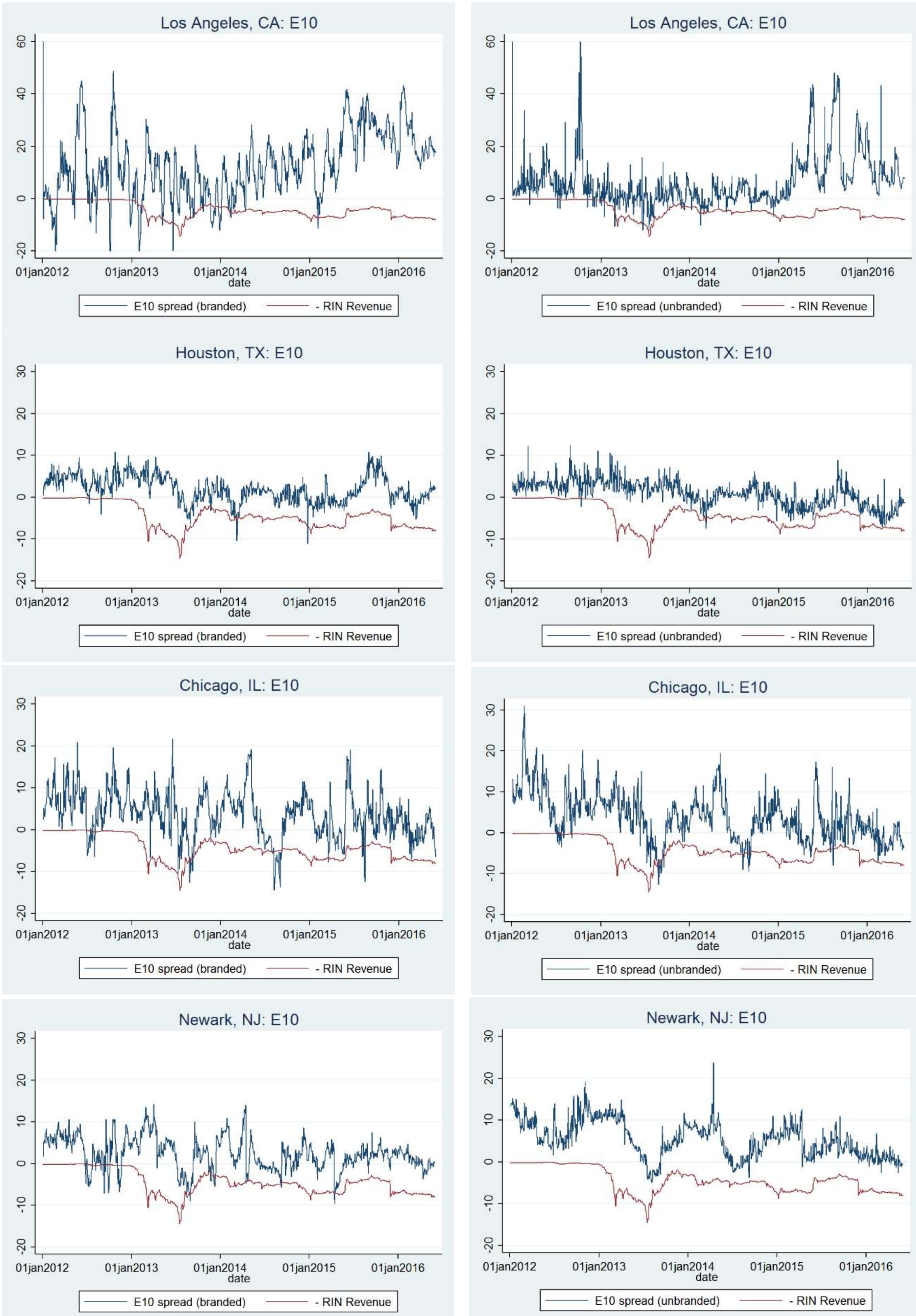


Figure 4: Rack spreads on E10 in four major cities (cents per gallon)

Table 1 shows average RIN revenue and average spreads for several cuts of the data and for the three RIN price periods highlighted in Figure 3. Average RIN revenue was 6.9 cents/gallon higher in the RIN shock period than in 2012; it was 5c/gal higher in the high-RIN price period than in 2012. Under full pass-through, we expect the change in the spread between periods to be the negative of the change in RIN revenue.

The entries in Table 1 are simple averages and they have no measures of precision associated with them. In the next section, when we present our regression results, we present rigorous estimates of pass-through. The objective of this table is to display some descriptive characteristics of the data. The decline in spreads is larger for unbranded than for branded fuel, suggesting that the pass-through is more complete for unbranded fuel. Average margins in the West are much larger than the other regions, as was apparent for Los Angeles in Figure 4. As we show in the next section, this region also has a very high variance, which causes our pass-through estimates to be imprecise.

Table 1: E10 Spread Summary Statistics

	Full Sample	Sub-Periods			Pass-Through	
		Low RIN Price	**RIN Shock**	**High RIN Price**	**RIN Shock**	**High RIN Price**
	1/12-5/16	1/12-12/12	1/13-8/13	9/13-5/16		
	(1)	(2)	(3)	(4)	(3)-(2)	(4)-(2)
RIN Revenue (0.1*RIN price)	4.4	0.3	7.1	5.3	6.9	5.0
Branded Spreads						
Scope 1: 10 Large Cities	5.4	6.8	4.2	5.1	-2.6	-1.7
Scope 2: E85 Cities	0.6	2.6	-0.5	0.2	-3.1	-2.5
Scope 3: 3 States (IA, IL, MN)	1.4	3.8	1.2	0.5	-2.6	-3.3
West	7.4	8.1	1.7	8.6	-6.4	0.6
Gulf	2.5	5.2	2.9	1.5	-2.3	-3.7
Midwest	-0.9	1.5	-1.7	-1.5	-3.2	-3.0
East	2.8	3.9	2.3	2.5	-1.5	-1.4
Unbranded Spreads						
Scope 1: 10 Large Cities	4.7	8.5	4.1	3.5	-4.4	-5.0
Scope 2: E85 Cities	3.1	5.2	3.7	2.2	-1.5	-3.0
Scope 3: 3 States (IA, IL, MN)	2.8	5.6	3.7	1.6	-1.9	-4.0
West	7.2	10.9	4.8	6.5	-6.1	-4.3
Gulf	2.5	5.0	3.8	1.3	-1.2	-3.7
Midwest	0.9	3.8	1.5	-0.3	-2.3	-4.0
East	5.2	6.9	5.0	4.6	-1.9	-2.2

Note: cents/gallon. The cities in each scope and each region are listed in Appendix Tables A1 and A2.

5. E10 RIN Pass-through

We present several estimates of proportion of RIN revenue that is passed through in E10. First, we estimate models of city-average prices that pool data across multiple cities. Next, we present estimated pass-through for each city in Scopes 1 and 2 (see Appendix Table A1). Finally, for the four largest cities (New York, Los Angeles, Chicago, and Houston), we present the estimated pass-through for each rack supplier.

5.1. Econometric model

Our main regression model is

$$spread_{jt} = \alpha_j + \beta R_{t-d} + \beta_0 \Delta R_t + \beta_1 \Delta R_{t-1} + \ldots + \beta_{d-1} \Delta R_{t-d+1} + \varepsilon_{jt}\ , \qquad (4)$$

where j denotes the city, $\Delta R_t = R_t - R_{t-1}$ and recall that R=δρ denotes RIN revenue. This specification allows for RIN pass-through not to be instantaneous and possibly take several weeks. Indeed, there is evidence in the fuel market for the pass-through of input costs to take several weeks (Borenstein et al., 1997). The total pass-through of the RIN is measured as β, and the coefficients β_j indicate the cumulative pass-through after j days. We investigated additional specifications that allowed a seasonality in the spreads. These models produced very similar results to those reported in this section, so we proceed without including seasonal terms.

The regression equation in (4) imposes complete pass-through of the gasoline blendstock and ethanol prices. Table 2 shows that the data support this assumption by reporting results from models that do not impose it using a pooled sample of 20 large cities. We include one city from each of the 20 Metropolitan Statistical Areas (MSA) included in Scopes 1 and 2 (see Appendix Table A1), and weight by MSA population. We use 10 lags in the distributed lag specification, but the results are very similar if we increase the number of lags to 30. We compute standard errors by clustering at the year-month level. As discussed in Section 4, the first half of 2013 was the first time that the markets had experienced RIN prices substantially greater than zero. To allow for the possibility that market participants did not adapt immediately to this new market reality, we report results both for the full sample and a sample that omits the RIN shock period (1/1/13-8/31/13).

We report in the odd-numbered columns of Table 2 the long-run pass-through estimates from

$$p_{jt}^f = \alpha_f + \beta R_{t-d} + \gamma w_{j,t-d}^g + \theta w_{j,t-d}^e + \beta(L)\Delta R_t + \gamma(L)\Delta w_{jt}^g + \gamma(L)\Delta w_{jt}^e + \varepsilon_{jt}\ , \qquad (5)$$

where $w_{j,t-d}^g = 0.9 p_{j,t-d}^g$ and $w_{j,t-d}^e = 0.1 p_{j,t-d}^e$. Alternatively, we report in the even-numbered columns of Table 2 results from

$$p_{jt}^{f} = \alpha_f + \beta R_{t-d} + \phi wc_{j,t-d} + \beta(L)\Delta R_t + \phi(L) wc_{jt} + \varepsilon_{jt}\ , \tag{6}$$

where $wc_{jt} = 0.9 p_{jt}^{g} + 0.1 p_{jt}^{e}$ is the wet fuel cost of E10. The estimated long-run pass-through the wet fuel price is not significantly different from one, whether we impose the blend ratio or not.

We use population weights as proxies for consumption volumes, which we do not observe. For the sample period that drops the RIN shock period, Table 2 shows that pooling the data and weighing observations according to the population yields a RIN pass-through between 0.75 and 0.80, regardless of whether fuel is branded or not. The pass-through is not precisely estimated as we cannot reject that it is not different than 1 or not different than 0.5. These results do not inform about spatial difference in the pass-through rate and possible causes for an imperfect pass-through. We look into these questions and the robustness of our results in alternative specifications of the regression model.

Table 2: Population-Weighted E10 Pass-through Estimates from Unrestricted Models

	Full Sample				Drop Jan-Aug 2013			
	Branded		Unbranded		Branded		Unbranded	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Long-Run pass-through								
0.1 RIN ($R_{t\text{-}10}$)	0.470	0.431	0.431	0.657	0.796	0.783	0.749	0.788
	(0.108)	(0.108)	(0.108)	(0.094)	(0.154)	(0.131)	(0.154)	(0.135)
0.9 BOB ($w_{j,t-10}^{g}$)	0.994		1.012		0.985		1.009	
	(0.005)		(0.007)		(0.006)		(0.008)	
0.1 Eth ($w_{j,t-10}^{e}$)	1.097		1.053		1.034		1.000	
	(0.066)		(0.077)		(0.073)		(0.085)	
wet fuel cost		1.001		1.014		0.989		1.008
		(0.004)		(0.005)		(0.006)		(0.006)
Constant	4.653	4.988	2.896	3.310	9.099	8.927	5.025	5.204
	(1.489)	(1.362)	(1.438)	(1.359)	(2.112)	(1.931)	(1.753)	(1.750)

Note: Models in (5) and (6) estimated separately for branded and unbranded fuel. Dependent variable is E10 price. Metropolitan Statistical Area population from 2010 census used as weights. Sample includes one city from each of the 20 MSAs included in Scopes 1 and 2 (see Appendix Table A1). For the New York MSA, we include Newark and not Long Island or New York. For the Miami MSA, we include Miami but not Port Everglades. For each of the California cities, we include a dummy variable for the period after the Torrance refinery explosion (2/18/15 through the end of the sample). Standard errors clustered by year-month in parentheses. All regressions include 10 distributed lags of each variable.

5.2. E10 RIN Pass-through: Pooled Models

Based on the results in Table 2, we impose full pass-through of the wet fuel cost in subsequent regressions. Table 3 presents estimates from the regression in (4) for the same 20 large cities as in Table 2. In the full sample, we estimate RIN pass-through in these 20 large cities to be 0.46 for branded fuel and 0.77 for unbranded fuel. The estimates increase to 0.63 and 0.92 when we drop the RIN shock period, which implies that pass-through since September 2013 was better than it was in the first part of 2013. Compared to Table 2, the unbranded estimate is slightly higher and the branded estimate is slightly lower.

These estimates have wide confidence intervals. For branded fuel in the sample that excludes the RIN shock period, the 95% confidence interval is [0.24, 1.01] and for unbranded fuel it is [0.70, 1.14]. These intervals are wide because the RIN subsidy in E10 relatively small; it averages $0.05/gal in the high-RIN-price period since September 2013. The small per-gallon magnitude of this subsidy makes it impossible to estimate precisely the proportion that is passed through.

The pass-through dynamics are estimated quite imprecisely, but the point estimates suggest that the long-run pass-through occurs within a week. The last column of Table 3 shows that, for unbranded fuel, an estimated 38% of a RIN shock is passed through on the same day. The estimated cumulative pass-through increases to 73% the next day and 87% two days later. However, the confidence interval on the contemporaneous pass-through is [-0.47, 1.22], followed by [0.03, 1.42] and [0.20, 1.54] in the subsequent two days. On branded fuel, the point estimates suggest full pass-through on the same days as a RIN price shock, but the standard errors on this estimate are even larger than for unbranded fuel. Even though these dynamic estimates are imprecise, they suggest that RIN pass-through occurs within a week. We continue to include the lag terms in subsequent regressions because they absorb the impacts of short-run RIN shocks and thereby enable more precise estimation of the long-run pass-through.

The Torrance dummy variables reveal that the Los Angeles spread was about 16 cents higher for branded fuel and 13 cents higher for unbranded fuel during the refinery outage. The San Diego premium was lightly smaller at 12 cents and 11 cents, and for San Jose it was 5 cents and -2 cents. If we drop Los Angeles and San Diego from the sample, we obtain pass-through estimates of 0.61 for branded fuel and 0.87 for unbranded fuel in the sample that excludes the RIN shock period. Thus, the inclusion of these Southern California cities has little effect on our results.

Table 3: Population-Weighted E10 Pass-through

	Full Sample		Drop Jan-Aug 2013	
	Branded	Unbranded	Branded	Unbranded
Long-Run Pass-through				
R_{t-10}	0.46	0.77	0.63	0.92
	(0.16)	(0.10)	(0.20)	(0.11)
Pass-Through Dynamics				
ΔR_t	0.40	-0.18	1.07	0.38
	(0.51)	(0.23)	(0.70)	(0.43)
ΔR_{t-1}	0.57	0.26	1.22	0.73
	(0.45)	(0.26)	(0.48)	(0.36)
ΔR_{t-2}	0.46	0.20	1.35	0.87
	(0.50)	(0.23)	(0.56)	(0.34)
ΔR_{t-3}	0.53	0.37	1.27	0.86
	(0.46)	(0.22)	(0.55)	(0.37)
ΔR_{t-4}	0.38	0.42	1.14	0.73
	(0.46)	(0.20)	(0.51)	(0.35)
ΔR_{t-5}	0.36	0.50	1.34	1.18
	(0.42)	(0.32)	(0.65)	(0.36)
ΔR_{t-6}	0.24	0.62	1.00	1.08
	(0.35)	(0.18)	(0.53)	(0.31)
ΔR_{t-7}	0.05	0.32	0.84	0.78
	(0.43)	(0.20)	(0.58)	(0.35)
ΔR_{t-8}	0.07	0.20	0.71	0.74
	(0.47)	(0.24)	(0.51)	(0.30)
ΔR_{t-9}	0.22	0.37	0.62	0.90
	(0.51)	(0.29)	(0.73)	(0.34)
Torrance Dummy (LA)	15.72	13.23	15.93	13.56
	(1.99)	(2.22)	(2.05)	(2.29)
Torrance Dummy (SD)	11.84	10.65	12.32	11.25
	(2.05)	(2.68)	(2.09)	(2.75)
Torrance Dummy (SJ)	4.82	-1.78	4.99	-1.60
	(1.34)	(1.16)	(1.49)	(1.37)
Constant	5.69	7.29	6.29	7.65
	(0.95)	(0.50)	(1.04)	(0.55)
Observations	25,081	25,078	21,217	21,214

Note: Metropolitan Statistical Area population from 2010 census used as weights. Sample includes one city from each of the 20 MSAs included in Scopes 1 and 2 (see Appendix Table A1). For the New York MSA, we include Newark and not Long Island or New York. For the Miami MSA, we include Miami but not Port Everglades. For each of the California cities, we include a dummy variable for the period after the Torrance refinery explosion (2/18/15 through the end of the sample). Standard errors clustered by year-month in parentheses.

One potential concern with the regression equation in (4) is that coincident trends could confound the pas through of the RIN price. If the spread would have trended downwards regardless of what happened to RNI prices, then the regression in (4) would attribute that trend to RINs. A robust way to account for omitted trends is to estimate the model in first differences, i.e., to estimate

$$\Delta spread_{ft} = \alpha_f + \beta \Delta R_{t-d} + \beta_0 \Delta^2 R_t + \beta_1 \Delta^2 R_{t-1} + \ldots + \beta_{d-1} \Delta^2 R_{t-d+1} + \varepsilon_{ft}\,, \qquad (5)$$

We report results from this specification in Appendix Table A3. The estimate pass-through coefficients are smaller than those in Table 3, but they are estimated very imprecisely. The 95% confidence interval for branded fuel is [-1.06, 1.22] and the interval for unbranded fuel is [-0.54, 1.18] in the sample that excludes the RIN shock period. These intervals include both zero and complete pass-through, so they provide little information. We have no reason to believe that spreads would have trended downwards in the absence of the RIN trend, so we report results from levels regressions like (4) in the remainder of the paper.

Figure 4 presents estimates of the parameter β for three different cuts of the data. Each diamond in the figure is an estimate of β a different regression and the vertical bars indicate 95% confidence intervals. Column 1 of Figure 4 shows results for the full sample and column 2 shows results for the sample that drops the RIN shock period. We highlight five results from these regressions. In the remainder of the paper, we focus on results that exclude the RIN shock period.

First, dropping the RIN shock period from the sample increases the pass-through estimate in all but one case. The single exception is the East region, which we discuss further below. Second, in every case, the pass-through to unbranded fuel prices is higher than the pass-through to branded prices. This finding may reflect stronger competition in the unbranded market. A retail station purchasing unbranded fuel will shop for the lowest price, whereas a branded retail station has little choice about where to buy fuel.

Third, average pass-through in the three states (MN, IA, IL) is close to complete for both branded and unbranded fuel. The point estimates are 0.90 for branded fuel and 1.02 for unbranded. These three states also tend to have the penetration of high-ethanol-blend fuels. For the cities in the E85 scope, estimated pass-through is somewhat lower, at 0.54 for branded and 0.76 for unbranded fuel. The estimated pass though in the 10 Cities scope is slightly higher than for the E85 Cities scope.

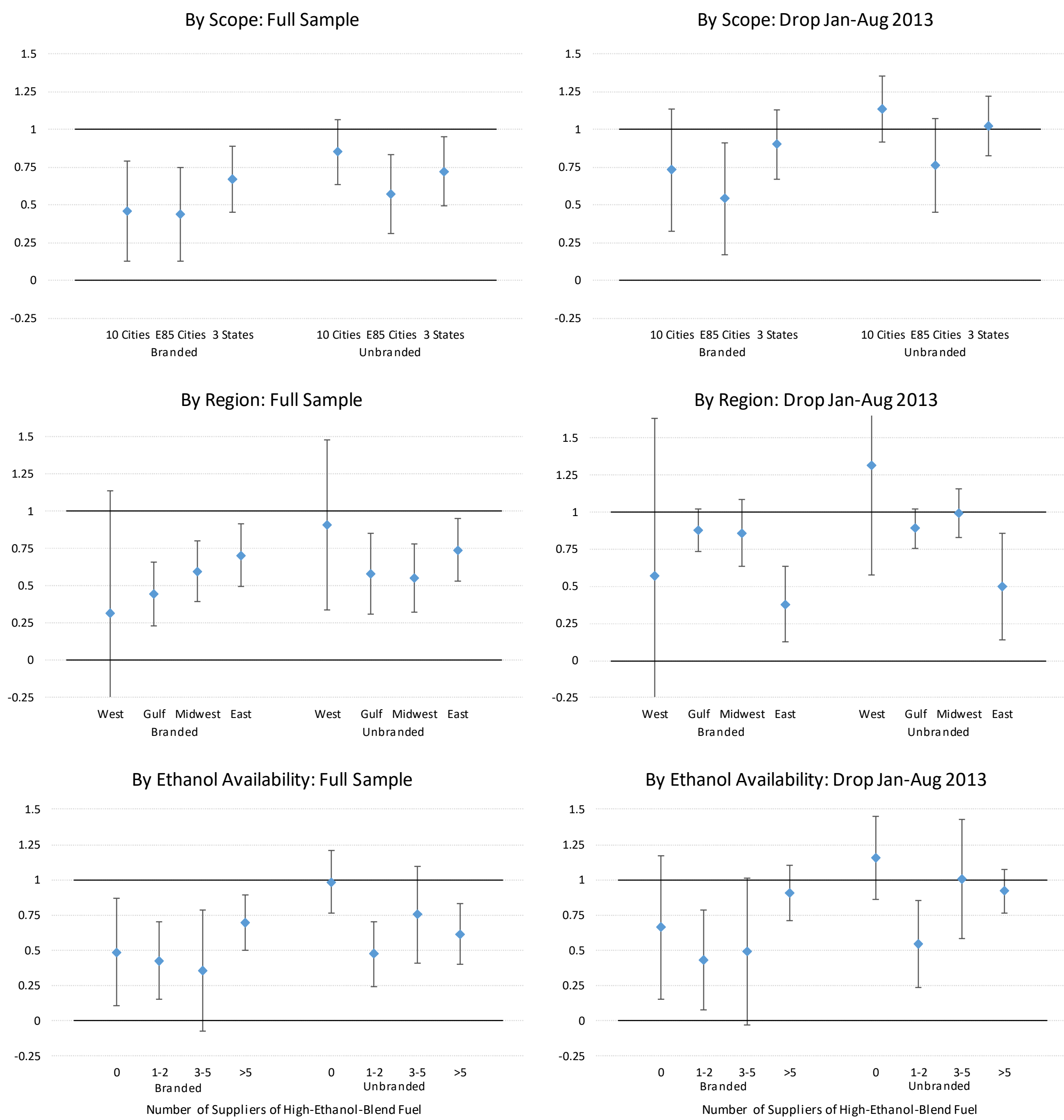


Figure 4: Long-Run E10 Pass-Through to E10 Rack-City Prices – Pooled Models

Note: Regressions contain city fixed effects and 10 lags. For each of the California cities, we include a dummy variable for the period after the Torrance refinery explosion (2/18/15 through the end of the sample). Standard errors clustered by year-month. The first column results use all data in the interval 1/1/12-5/31/16, whereas the second column results include 1/1/12-12/31/12 and 9/1/13-5/31/16. The cities in each scope, region, and ethanol availability category are shown in Appendix Tables A1 and A2.

Fourth, pass-through is close to one in the Gulf and Midwest regions, incomplete in the East, and highly uncertain in the West. Using the sample that drops the RIN shock period, the estimated pass-through coefficients in these two regions are 0.88 and 0.86 for branded fuel and 0.89 and 0.99 for unbranded fuel. Estimated pass-through in the East is significantly less than one, at 0.38 and 0.50 for branded and unbranded fuel, respectively. The West estimates are very imprecise, due in large part to the highly variable margins in many Western markets. The branded pass-through estimate is 0.57, but the 95% confidence interval ranges from -0.49 to 1.63. For unbranded fuel in the West, the confidence interval ranges from 0.58 to 2.06.

Fifth, in cities with more than five suppliers offering high-blend-ethanol fuel, the pass-through is close to complete. As shown in Figure 2, these cities are in the middle of the country and close to where ethanol is produced. For cities with fewer firms offering ethanol products, estimated pass-through is about 0.5 for branded fuel. The pattern is less clear for unbranded fuel, where estimated pass-through is less than complete for cities with 1-2 ethanol suppliers (0.54), but complete for cities with no high-blend –ethanol suppliers.

5.3. E10 RIN Pass-through – City Models

The top row Figure 5 shows pass-through estimates for each of the large cities in Scope 1, and the bottom row shows estimates for each of the E85 cities in Scope 2. The results reinforce the findings displayed in Figure 4.

Estimated pass-through is close to complete in the three Midwest cities. Minneapolis produces the smallest estimated pass-through, but it is estimated much less precisely than the Des Moines and Chicago parameters. In the Gulf region, the estimates for Austin, Oklahoma City and Wichita all have estimated pass-through coefficients close to one. The Houston estimate is statistically less than one for both branded and unbranded fuel, as is Dallas for branded fuel. Notably, Oklahoma City and Wichita, which exhibit full pass-through, also had more suppliers of high-ethanol-blends than the Texas cities. These two cities had more than five suppliers of high-ethanol-blends at the rack, whereas Austin and Houston had three and Dallas had two.

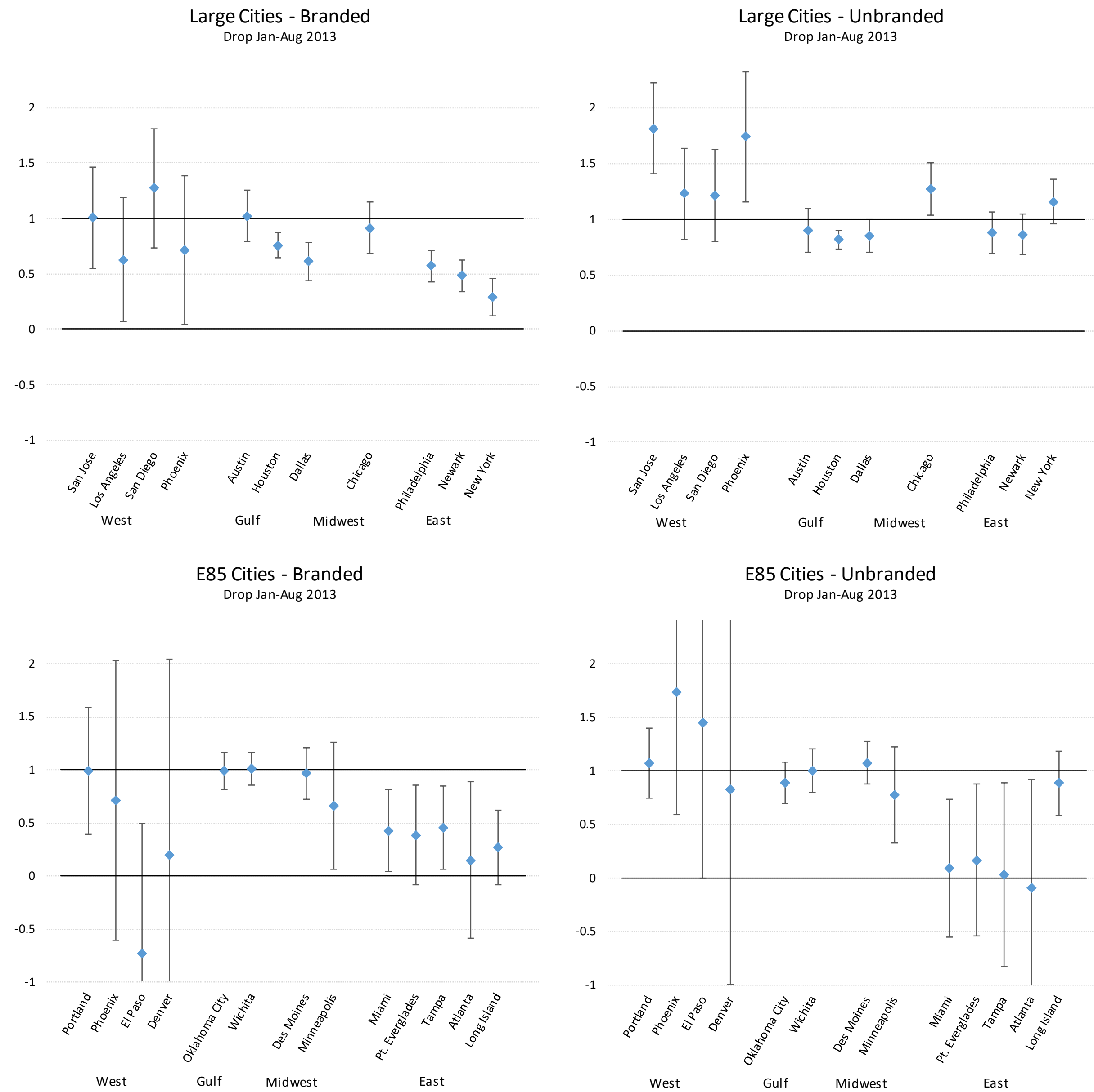


Figure 5: Long-Run E10 Pass-Through to E10 Rack-City Prices – City Models

Note: The first row includes the cities in Scope 1 and the second row includes the cities in Scope 2 (see Appendix Table A1). Regressions contain 10 lags. Standard errors estimated using Newey-West with 30 lags. Sample period: 1/1/12-12/31/12 and 9/1/13-5/31/16. For each of the California cities, we include a dummy variable for the period after the Torrance refinery explosion (2/18/15 through the end of the sample).

The Eastern cities exhibit strong differences by branding and geography. For unbranded fuel in Philadelphia and the New York area, estimated pass-through is complete. However, estimated pass-through in branded fuel prices is less than 0.6 in each of these cities and the confidence interval does not include one. In Atlanta and the Florida cities, estimated pass-through is less than 0.5 in all cases. The results from these southeastern cities are less precise than their northeastern counterparts. This likely reflects the fact that Florida is no connected to the rest of the country by pipeline. Most gasoline consumed in Florida travels by ship from Gulf Coast refineries. Atlanta lies along the Colonial pipeline, which is the major carrier of gasoline from the Gulf Coast to the Northeast. However, for almost all of the sample, Atlanta required low-sulfur gasoline, which is a distinct product not consumed anywhere else. The idiosyncratic nature of this product likely contributes to the high volatility in Atlanta spreads.

Consistent with the pooled results in Figure 4, the western cities produce results with very wide confidence intervals. El Paso and Denver exhibit the widest confidence intervals. These two cities are somewhat isolated and have a local refinery that supplies a substantial proportion of the local supply. This feature means that the bulk gasoline spot prices we use in these markets may not always accurately reflect the marginal cost to blenders of acquiring gasoline blendstock. As a result, our estimated spreads are highly volatile and the estimated pass-through coefficients are imprecise. The Phoenix estimate is almost as imprecise as those for El Paso and Denver. Similar to the Atlanta region, the Phoenix area requires an idiosyncratic gasoline product to meet air-quality objectives, which appears to generate volatile spreads.[7]

On the West Coast, we find full pass-through for Portland for both branded and unbranded fuels. The estimates for the California cities are more precise than El Paso, Denver, and Phoenix, but still much less precise than those from the Gulf or Midwest regions. For branded fuel, the 95% confidence interval includes one in each of the three cities. For unbranded fuel the estimated pass-through coefficients exceed one. The Los Angeles and San Diego estimates become negative if we omit the Torrance-explosion dummy variable. This result arises because the Torrance explosion occurred at the end of the sample when RIN prices were high. However, it is clear that spreads were high because of the explosion and not because of RIN prices, so it is important to control for the explosion, as we do.

[7] For both Atlanta and Phoenix, we use gasoline blendstock prices that are specific to those markets (see Table A1), so this volatility is not caused by using a generic blendstock price to compute the spread.

5.4. E10 RIN Pass-through – Suppliers Within Cities

Figure 6 reports estimates by supplier for the four largest cities in the US: Loa Angeles, Houston, Chicago, and Newark. We estimate a separate regression for each supplier at each terminal that posted prices on at least 800 out of the 909 days in the sample period. There are multiple terminals in each city and some suppliers post prices at multiple terminals. Such suppliers enter Figure 6 for each terminal at which they post. To preserve firm anonymity, we randomly order the suppliers designate them by number.

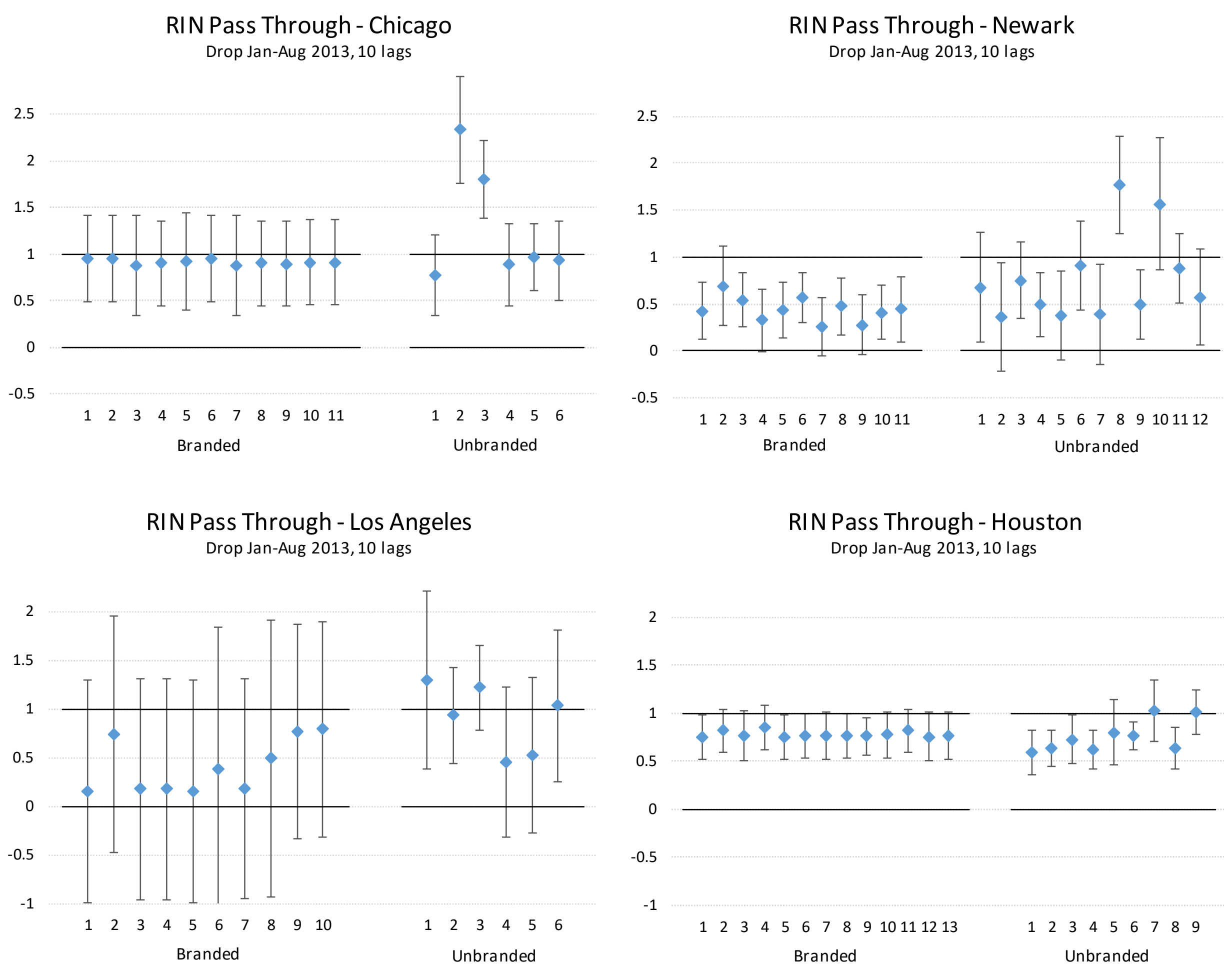


Figure 6: Long-Run E10 Pass-Through to E10 Supplier Prices

Note: Separate regression for each supplier at each terminal that had at least 800 daily observations (maximum number of observations is 909). Suppliers are ordered randomly to preserve anonymity. Regressions contain 10 lags. Standard errors estimated using Newey-West with 30 lags. Sample period: 1/1/12-12/31/12 and 9/1/13-5/31/16. For Los Angeles, we include a dummy variable for the period after the Torrance refinery explosion (2/18/15 through the end of the sample).

The pass-through coefficients on branded fuel are very similar within each city, especially for Chicago and Houston, which are the two with the highest average pass-through. This finding reflects the very similar, and often identical, prices that are posted for branded fuel across suppliers. It suggests that branded suppliers pay close attention to each other when posting prices. Los Angeles is an exception to this observation – the branded prices in Los Angeles show quite variable pass-through, although the confidence intervals are very wide.

Table 3 and Figure 4 showed that the average pass-through in unbranded fuel is higher than in branded. Figure 6 shows that unbranded pass-through is also much more variable than its branded counterpart. It is possible that the posted prices overstate the variation in prices paid because low volumes may transact at some of these prices.

5.5. E10 RIN Pass-through – Terminal Competition

In this section, we investigate two hypotheses that could explain differences in E10 pass-through across cities. First, we investigate whether the pass-through is higher in cities with more retail stations offering E85. Second, we whether pass-through is better in cities with more open terminals.

Figure 4 shows that cities with multiple parties posting high-blend-ethanol prices tend to have better pass-through than cities with fewer high-blend-ethanol suppliers. An alternative measure of high-ethanol-blend activity is the number of stations close to the terminal that offer E85. More E85 activity may elp promote competition in ethanol sales and lead to more RIN pass-through. However, Table 4 shows that pass-through is not significantly different in cities with more E85 stations.

We do not have a direct measure of the openness of terminals in a city. Because closed terminals tend to have only one supplier, we use as a proxy for openness the average number of suppliers per terminal. If a city has a high average number of suppliers per terminal then it suggests that multiple suppliers post prices at each terminal, which is a sign of openness. When computing this statistic, we do not account for corporate relationships among the suppliers because for most suppliers we do not know these relationships.[8] Thus, this measure of openness is imprecise. Table 4 shows no significant increase in pass though for locations with a high number of suppliers per terminal. We conclude that pass-through is high through the three Midwestern states, and we see no evidence that it variaes according to these measures of competition.

[8] For example, if Chevron and Texaco are listed as suppliers at a terminal, we would count that as two suppliers even though in the case of these two companies we know that they are the same organization.

Table 4: E10 Pass-through in Midwestern States

	Br.	Unbr.	Br.	Unbr.	Br.	Unbr.
Long-Run RIN pass-through						
$R_{t\text{-}10}$	0.92	0.99	0.90	0.99	0.84	1.06
	(0.12)	(0.11)	(0.11)	(0.10)	(0.13)	(0.14)
Interactions						
(High E85 Stations within 25 mi)*$R_{t\text{-}10}$	-0.03	0.08				
	(0.05)	(0.06)				
(High E85 stations within 75 mi)*$R_{t\text{-}10}$			0.01	0.08		
			(0.04)	(0.06)		
(High ratio of suppliers to terminals)*$R_{t\text{-}10}$					0.13	-0.08
					(0.11)	(0.13)
Constant	4.95	6.74	4.95	6.74	4.95	6.75
	(0.54)	(0.47)	(0.54)	(0.47)	(0.54)	(0.47)
Observations	36,166	34,918	36,166	34,918	36,166	34,918
Number of Cities	39	38	39	38	39	38

Note: Sample is cities in Scope 3 (see Appendix Table A1). For the interactions terms "high" is defined as above the median. The ratio of suppliers to terminals equals the total number of supplier-terminal combinations in a city divided by the total number of terminals. When computing the supplier/terminal totals, we weight by the number of days that each supplier/terminal post prices. Regressions include city fixed effects and 10 distributed lags. Standard errors clustered by year-month in parentheses. Br. denotes branded and Unbr. denotes unbranded.

5.6. High-Ethanol-Blend RIN Pass-through

As shown in Figure 2, suppliers post prices for high-ethanol fuel blends in numerous cities. These products range from E60 to E85 in increments of five. The most offered products are E70 and E75. Figure 7 plots the rack spread for branded and unbranded E70 in Minneapolis, computed as in (1) with δ=0.7. The figure shows strong pass-through for branded fuel in the last two years of the sample, but little evidence of any pass-through during the RIN shock period in 2013. In contrast, the unbranded product shows much less correlation between the spread and RIN revenue.

Visual inspections of the data revealed substantial heterogeneity across suppliers in each market. This heterogeneity means that city average prices often obscure the pass-through for individual suppliers. For this reason, we report in Figure 8 the estimated pass-through results for each supplier in each market. In most markets, some suppliers fully pass-through the RIN and some do not. Lade and Bushnell (2016) find complete pass-through of the RIN to E85 prices in Midwestern cities. Li and Stock (2017) find a similar result for Minneapolis. Thus, we expect that most retailer are purchasing from the suppliers that pass-through the RIN.

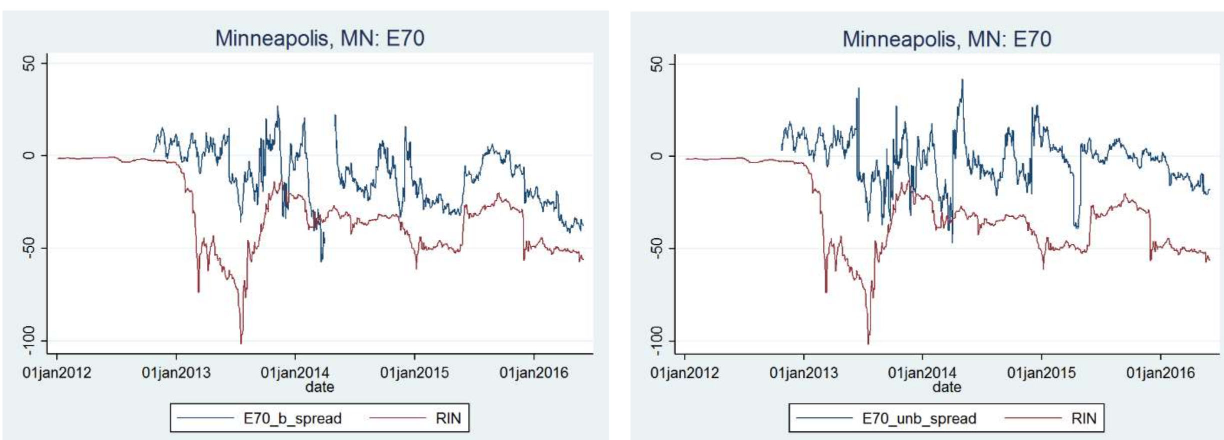
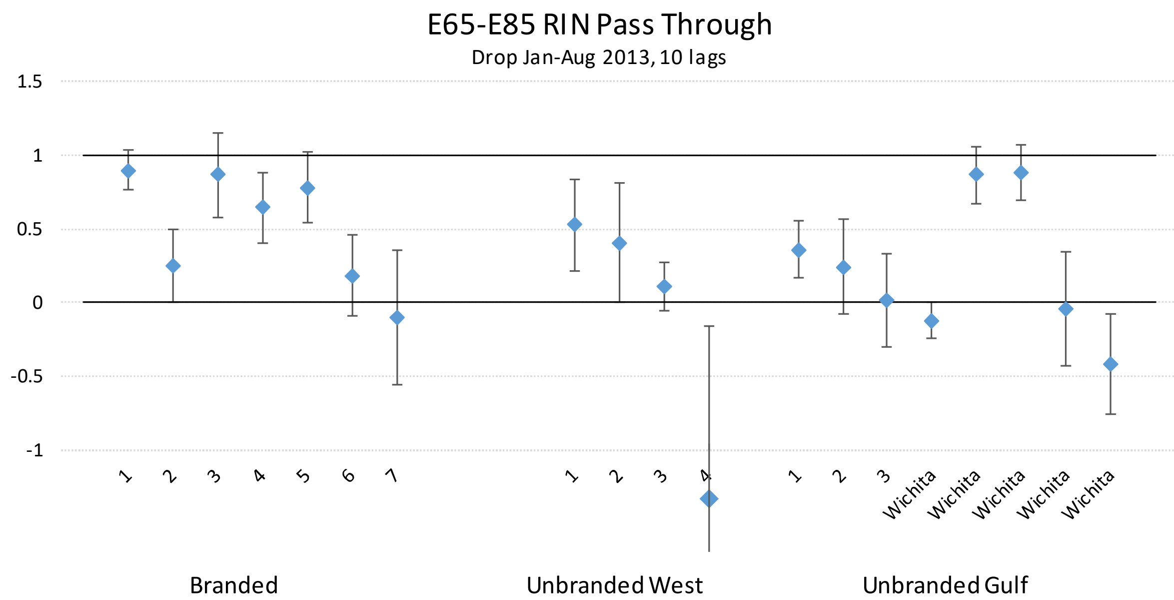


Figure 7: Rack spreads on E70 in Minneapolis (cents per gallon)

Note: The left figure is for branded fuel and the second figure is for unbranded. The red line is -0.7 times the RIN price.



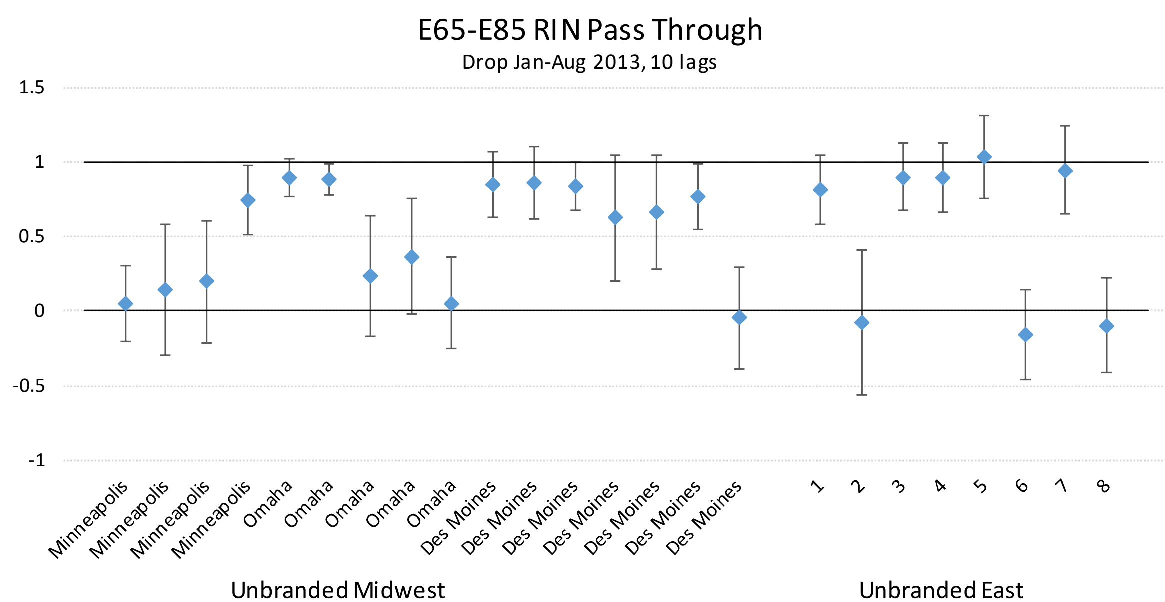


Figure 8: Long-Run E65-E85 Pass-Through by Supplier

Note: Separate regression for each supplier at each terminal for each fuel grade that had at least 400 daily observations (maximum number of observations is 909). Suppliers are numbered in cities with fewer than four suppliers to preserve anonymity. Regressions contain 10 lags. Standard errors estimated using Newey-West with 30 lags. Sample period: 1/1/12-12/31/12 and 9/1/13-5/31/16. We include cities in Scope 2 (see Appendix Table A1).

6. Conclusion

We estimate the RIN prices are fully passed through the E10 rack prices in the Midwest and the Gulf. We find less than perfect pass-through in the East and imprecise results in the West due to the noise in the data. Overall, average pass-through across 20 large cities (population-weighted) is 0.63 for branded fuel and 0.92 for unbranded fuel. Those national estimates are imprecise, and are consistent with low pass-through rates and with full pass-through. When we look at pass-through regionally, however, we find significant differences across regions, with essentially complete pass-through at the rack in the Gulf and Midwest, and less than complete pass-through in the East. High pass-though also aligns with the availability of higher blends at the rack.

Our finding of incomplete pass-through at the rack is informative about the current RIN system. In particular, these findings indicate that, at many terminals, fuel suppliers are exercising market power and retaining some of the RIN premium. As a result, the RIN value is not being fully passed through to consumers, at least at some racks in some locations, such as the East Coast. The point of obligation is irrelevant when there is complete pass-through. By themselves, however, these findings are not sufficient to conclude that shifting the point of obligation from refiners and importers downstream to the owner of the fuel just above the rack would improve pass-through and economic efficiency. There are other potential causes of incomplete pass-through that are independent of the RIN system, and identifying those causes goes beyond the scope of this paper.

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Table A1: Cities in Dataset by Scope

Rack City	St.	E10 Product	BOB Product	BOB Source	BOB Spot Market	Ethanol Spot Market
Scope 1: 10 Large Cities						
Austin	TX	CBOB Ethanol 10%	Unleaded Regular	SRI	Gulf Coast	Gulf Coast
Chicago	IL	RFG Ethanol 10%	RBOB Unleaded Regular	SRI	Chicago	Chicago
Dallas	TX	RFG Ethanol 10%	RBOB Unleaded Regular	SRI	Gulf Coast	Gulf Coast
Houston	TX	RFG Ethanol 10%	RBOB Unleaded Regular	SRI	Gulf Coast	Gulf Coast
Los Angeles	CA	CARFG Ethanol 10%	CARBOB Regular Unleaded	SRI	Los Angeles	Los Angeles
New York	NY	RFG Ethanol 10%	RBOB Unleaded Regular	SRI	NY Harbor Barge	NY Harbor Barge
Newark	NJ	RFG Ethanol 10%	RBOB Unleaded Regular	SRI	NY Harbor Barge	NY Harbor Barge
Philadelphia	PA	RFG Ethanol 10%	RBOB Unleaded Regular	SRI	NY Harbor Barge	NY Harbor Barge
Phoenix	AZ	CBG Ethanol 10%	AZ RBOB Unleaded Regular	SRI	Los Angeles	Los Angeles
San Diego	CA	CARFG Ethanol 10%	CARBOB Regular Unleaded	SRI	Los Angeles	Los Angeles
San Jose	CA	CARFG Ethanol 10%	CARBOB Regular Unleaded	SRI	San Francisco	Los Angeles
Scope 2: E85 Cities						
Atlanta	GA	CBOB Ethanol 10% LS	CBOB Unl	Spot	Gulf Coast	Chicago
Denver	CO	Conv. Ethanol 10%/ CBOB Ethanol 10%	Unleaded Regular/Sub-Octane Unleaded Regular	Spot	Group 3	Chicago
Des Moines	IA	Conv. Ethanol 10%/ CBOB Ethanol 10%	Unleaded Regular/Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
El Paso	TX	CBOB Ethanol 10%	CBOB Unl	SRI	Gulf Coast	Chicago
Long Island	NY	RFG Ethanol 10%	RBOB Unleaded Regular	SRI	NY Harbor Barge	NY Harbor Barge
Miami	FL	CBOB Ethanol 10%	CBOB Unl	SRI	Gulf Coast Waterborne	Tampa Barge
Minneapolis	MN	Conv. Ethanol 10%/ CBOB Ethanol 10%	Unleaded Regular/Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Oklahoma City	OK	Conv. Ethanol 10%/ CBOB Ethanol 10%	Unleaded Regular/Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Portland	OR	Conv. Ethanol 10%/ CBOB Ethanol 10%	Sub-Octane Unleaded Regular	SRI	Pacific Northwest	Pacific Northwest
Pt. Everglades	FL	CBOB Ethanol 10%	Unleaded Regular	Spot	Gulf Coast Waterborne	Tampa Barge
Tampa	FL	CBOB Ethanol 10%	CBOB Unl	SRI	Gulf Coast Waterborne	Tampa Barge
Wichita	KS	Conv. Ethanol 10%/ CBOB Ethanol 10%	Unleaded Regular/Sub-Octane Unleaded Regular	SRI	Group 3	Chicago

Note: Dallas enters the dataset as 3 separate cities “Dallas Metro”, “Dallas/Grapevine”, and “Dallas/Southlake”. Houston and Dallas are also in the E85 Cities dataset. Chicago, Des Moines and Minneapolis are also in the 3 States dataset. In fall 2013, the default E10 product switched from “Conv. Ethanol 10%” to “CBOB Ethanol 10%” in many cities. The corresponding BOB product switched from “Unleaded Regular” to “Sub-Octane Unleaded Regular” at the same time.

Table A1: Cities in Dataset by Scope (continued)

Rack City	St.	E10 Product	BOB Product	BOB Source	BOB spot market	Ethanol Spot Market
Scope 3: 3 States						
Bettendorf	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Council Bluffs	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Dubuque	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Ft. Madison	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	CBOB Unl	Spot	Chicago	Chicago
Iowa City	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Lemars	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Mason Cty	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Milford	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Sioux City	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Waterloo	IA	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Argo	IL	RFG Ethanol 10%	RBOB Unleaded Regular	Spot	Chicago	Chicago
Champaign	IL	CBOB Ethanol 10%	CBOB Unl	Spot	Chicago	Chicago
Decatur	IL	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Des Plaines	IL	RFG Ethanol 10%	RBOB Unleaded Regular	Spot	Chicago	Chicago
Heyworth	IL	CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Kankakee	IL	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Lemont	IL	RFG Ethanol 10%	RBOB Unleaded Regular	Spot	Chicago	Chicago
Lockport	IL	RFG Ethanol 10%	RBOB Unleaded Regular	Spot	Chicago	Chicago
Mt. Prospect	IL	RFG Ethanol 10%	RBOB Unleaded Regular	Spot	Chicago	Chicago
Norris City	IL	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	Spot	Group 3	Chicago
Robinson	IL	Conv. Ethanol 10%/CBOB Ethanol 10%	CBOB Unl	Spot	Chicago	Chicago
Rockford	IL	CBOB Ethanol 10%	CBOB Unl	Spot	Chicago	Chicago
Wood River	IL	RFG Ethanol 10%	RBOB Unleaded Regular	Spot	Group 3	Chicago

Note: Mason City enters the dataset as “Mason Cty/Clr.Lk.”. We dropped Ottumwa, IA, Ft. Dodge, IA and Foresview, IL due to incomplete data. Decatur enters the dataset as “Decatur/Forsythe”. In fall 2013, the default E10 product switched from “Conv. Ethanol 10%” to “CBOB Ethanol 10%” in many cities. The corresponding BOB product switched from “Unleaded Regular” to “Sub-Octane Unleaded Regular” at the same time.

Table A1: Cities in Dataset by Scope (continued)

Rack City	St.	E10 Product	BOB Product	BOB Source	BOB Spot Market	Ethanol Spot Market
Scope 3: 3 States (continued)						
Alexandria	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Duluth	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Mankato	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Marshall	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Moorhead	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Rochester	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Rosemount	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Roseville	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	Spot	Group 3	Chicago
Sauk Centre	MN	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Omaha	NE	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago
Sioux Falls	SD	Conv. Ethanol 10%/CBOB Ethanol 10%	Unleaded Regular/ Sub-Octane Unleaded Regular	SRI	Group 3	Chicago

Note: Rosemount enters the dataset as “Pn Bnd/FlntHlsRs”. Roseville enters the dataset as two separate cities “Rsvile/FlntHlsRs” and “Roseville/Magellan”. Duluth enters the dataset as three separate cities “Duluth”, “Duluth/Esko” and “Duluth/Wrenshall”. In fall 2013, the default E10 product switched from “Conv. Ethanol 10%” to “CBOB Ethanol 10%” in many cities. The corresponding BOB product switched from “Unleaded Regular” to “Sub-Octane Unleaded Regular” at the same time.

Table A2: Cities in Dataset by Geography and High-Ethanol-Blend Offerings

Region	
West	Portland, San Jose, Los Angeles, San Diego, Phoenix, El Paso, Denver
Gulf	Austin, Houston, Dallas, Oklahoma City, Wichita
Midwest	Omaha, Des Moines, Minneapolis, Chicago
East	New York, Newark, Long Island, Philadelphia, Atlanta, Tampa, Miami, Pt. Everglades
Number of Suppliers of High-Blend-Ethanol	
>5 Suppliers	Oklahoma City, Wichita, Omaha, Des Moines, Minneapolis
3-5 Suppliers	Phoenix, El Paso, Austin, Dallas, Chicago, Atlanta
1-2 Suppliers	Portland, Denver, Houston, Wood River, Long Island, Tampa, Miami, Pt. Everglades
0 Suppliers	San Jose, Los Angeles, San Diego, Philadelphia, Newark, New York

Table A3: Population-Weighted E10 Pass-through First Difference Models

	Full Sample		Drop Jan-Aug 2013	
	Branded	Unbranded	Branded	Unbranded
Long-Run Pass-through				
$R_{t\text{-}10}$	0.09	0.51	0.08	0.32
	(0.53)	(0.23)	(0.58)	(0.44)
Pass-Through Dynamics				
ΔR_t	0.21	-0.14	0.32	-0.25
	(0.15)	(0.14)	(0.30)	(0.32)
$\Delta R_{t\text{-}1}$	0.45	0.32	0.64	0.30
	(0.24)	(0.19)	(0.39)	(0.33)
$\Delta R_{t\text{-}2}$	0.34	0.26	0.76	0.41
	(0.27)	(0.17)	(0.57)	(0.26)
$\Delta R_{t\text{-}3}$	0.41	0.43	0.70	0.40
	(0.25)	(0.16)	(0.53)	(0.30)
$\Delta R_{t\text{-}4}$	0.24	0.47	0.65	0.29
	(0.27)	(0.13)	(0.60)	(0.33)
$\Delta R_{t\text{-}5}$	0.22	0.54	0.81	0.73
	(0.43)	(0.28)	(0.81)	(0.37)
$\Delta R_{t\text{-}6}$	0.10	0.67	0.47	0.62
	(0.58)	(0.20)	(0.73)	(0.36)
$\Delta R_{t\text{-}7}$	-0.11	0.35	0.37	0.34
	(0.49)	(0.20)	(0.76)	(0.38)
$\Delta R_{t\text{-}8}$	-0.09	0.22	0.21	0.27
	(0.49)	(0.23)	(0.61)	(0.40)
$\Delta R_{t\text{-}9}$	0.17	0.53	0.33	0.60
	(0.50)	(0.23)	(0.72)	(0.44)
Torrance Dummy (LA)	0.06	-0.01	0.07	-0.01
	(0.20)	(0.19)	(0.20)	(0.19)
Torrance Dummy (SD)	0.06	-0.05	0.07	-0.06
	(0.20)	(0.20)	(0.19)	(0.20)
Torrance Dummy (SJ)	0.05	-0.01	0.05	-0.01
	(0.15)	(0.10)	(0.15)	(0.12)
Constant	0.00	0.00	0.00	0.01
	(0.04)	(0.02)	(0.04)	(0.02)
Observations	25,061	25,058	21,197	21,194

Note: Metropolitan Statistical Area population from 2010 census used as weights. Sample includes one city from each of the 20 MSAs included in Scopes 1 and 2 (see Appendix Table A1). For the New York MSA, we include Newark and not Long Island or New York. For the Miami MSA, we include Miami but not Port Everglades. For each of the California cities, we include a dummy variable for the period after the Torrance refinery explosion (2/18/15 through the end of the sample). Standard errors clustered by year-month in parentheses.